TITLE: ENGINEERING A NEW MATERIAL FOR HOT GAS CLEANUP

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GRANT NO.: DE-FG26-99FT40587

PERIOD OF PERFORMANCE: July 1, 1999 – June 30, 2002 DATE: April, 2000

ABSTRACT

OBJECTIVE

The overall objective of this project is the engineering development of a superior calcium-based material for desulfurizing hot coal gas. The material should be capable of removing H_2S and COS from hot gas and should withstand repeated loading and regeneration. The project is built on the results of a previous investigation which showed that a promising material could be made by encasing a limestone pellet within a porous shell of a stronger but largely inert material. Specific tasks include the following:

1. Prepare and test numerous core-in-shell pellets in order to identify the best materials and composition for both the pellet core and pellet shell.
2. Optimize sorbent preparation conditions to obtain a strong, durable and highly reactive material which is also economical to use.
3. Conduct a thorough evaluation of the best sorbent material.

ACCOMPLISHMENTS TO DATE

Although a promising sorbent for hot gas desulfurization had been prepared in a previous study by a two-stage pelletization method which produced spherical pellets with a limestone core and a strong porous shell, the material displayed a gradual loss in reactivity and/or adsorption capacity when subjected to repeated loading and regeneration. The pellets had been made with a hydraulically setting, calcium aluminate cement as a binder. In order to prepare a more durable sorbent, other materials are presently being tested. Initial results indicate that a relatively strong shell material can be made by combining ultrafine alumina powder with somewhat coarser alumina particles and pulverized limestone and then sintering the mixture at 1373°K. Also it has been found that the compressive strength of the limestone core can be improved by incorporating some alumina powder in the core but with some loss in adsorptive capacity. Furthermore, it has been shown that the adsorptive capacity depends on the source and composition of the limestone.

SIGNIFICANCE TO FOSSIL ENERGY PROGRAM

The development of advanced integrated coal gasification combined-cycle (IGCC) power generating systems calls for a sorbent capable of removing H_2S and COS from coal gas at near gasifier operating temperature which can be 1255°K (1800°F) or more. Among various materials which have been proposed for this service, limestone offers several advantages including low cost and widespread availability. Moreover, after limestone is calcined, the resulting CaO in theory can capture 95% or more of the sulfurous species in coal gas when applied within a temperature range of 1070 to 1570°K (1470 to 2370°F). However, since lime is soft and friable, it has been widely regarded as a material to be used once and then discarded. Unfortunately, materials containing CaS cannot be placed directly in a landfill where they will react slowly with moisture and CO_2 under ambient conditions to form H_2S. By developing a calcium-based material which is a good sorbent as well as being regenerable and durable, hot gas cleaning can be greatly advanced which will improve the technical and economic feasibility of IGCC power generation.

PLANS FOR THE COMING YEAR

Other potential core materials and shell materials will be utilized for the preparation of sorbent pellets for testing and evaluation. The pellets will be tested for compressive strength, adsorption capacity, and ability to withstand repeated loading and regeneration. Consideration will be given to the optimization of preparation conditions.

ARTICLES, PRESENTATIONS, AND STUDENT SUPPORT

Conference Presentations

- T.T. Akiti, Jr., and T.D. Wheelock, "Development of a core-in-shell sorbent for desulfurizing hot coal gas," presented at the Annual Meeting of the Iowa Academy of Science, Des Moines, Iowa, April 21, 2000.
- J. Zhu, D. Hasler, and K. Constant, "Calcia and alumina composites for desulfurization of high temperature coal gas," presented at the Annual Meeting of the Iowa Academy of Science, Des Moines, Iowa, April 21, 2000.

Students Supported under this Grant

- T.T. Akiti, Jr., a graduate (Ph.D.) student in chemical engineering at Iowa State University
- David Hasler, a graduate (Ph.D.) student in chemical engineering at Iowa State University
- J. Zhu, a graduate (M.S.) student in materials science and engineering at Iowa State University
- Stephen Dak, an undergraduate student in chemical engineering at Iowa State University